

## BACKGROUND

The long-term objective of the U.S. AMLR field research program is to describe the functional relationships between Antarctic krill (*Euphausia superba*), their predators, and key environmental variables. The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food source; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. To refine these hypotheses a study area was designated in the vicinity of Elephant, Clarence, and King George Islands, and a field camp was established at Seal Island, a small island off the northwest coast of Elephant Island. From 1989-1996, shipboard studies were conducted in the study area to describe variations within and between seasons in the distributions of nekton, zooplankton, phytoplankton, and water zones. Complementary reproductive and foraging studies on breeding pinnipeds and seabirds were also accomplished at Seal Island.

Beginning in the 1996/97 season, the AMLR study area was expanded to include a large area around the South Shetland Islands, and a new field camp was established at Cape Shirreff, Livingston Island (Figure 1). Research at Seal Island was discontinued due to landslide hazards. Shipboard surveys of the pelagic ecosystem in the expanded study area are accomplished each season, as are land-based studies on the reproductive success and feeding ecology of pinnipeds and seabirds at Cape Shirreff. During the 1999/2000 season, the AMLR program also participated in a multi-nation, multi-ship survey of krill throughout the Scotia Sea, known as the CCAMLR 2000 survey.

## SUMMARY OF 2000 RESULTS

The Russian R/V *Yuzhmorgeologiya* was chartered to support the U.S. AMLR Program during the 1999/2000 field season. This was the first year of a new 5-year charter with the vessel operators after four successful previous seasons. Shipboard operations included: 1) participation in a multi-nation, multi-ship survey of Antarctic krill across the Scotia Sea; 2) a joint Zodiac/ship inshore survey of krill and oceanographic conditions near Cape Shirreff; 3) a region-wide survey of krill and oceanographic conditions in the vicinity of the South Shetland Islands; 4) calibration of acoustic instrumentation at the beginning and end of survey operations; and 5) shore camp support. Land-based operations at Cape Shirreff included: 1) observations of chinstrap and Adélie penguin breeding colony sizes, foraging locations and depths, diet composition, breeding chronology and success, and fledging weights; 2) instrumentation of adult penguins to determine winter-time migration routes and foraging areas; 3) observations of fur seal pup production and growth rates, adult female attendance behavior, diet composition, foraging locations and depths, and metabolic rates; 4) collection of female fur seal milk samples for determination of fatty acid signatures; 5) collection of fur seal teeth for age determination and other demographic studies; 6) tagging of penguin chicks and fur seal pups for future demographic studies; and 7) establishment of a weather station for continuous recording of meteorological data.

The CCAMLR 2000 Survey was conducted in collaboration with vessels from Japan, Russia and the UK (Figure 2). Sampling protocols, survey design, analysis procedures, and detailed results

are presented elsewhere (SC-CAMLR-XVIII, Annex 4, Appendices D and E; SC-CAMLR-XIX, Annex 4, Appendix G). Marine mammal and bird observers from the International Whaling Commission also participated on the survey. Oceanographic fronts located at the central axis (SACCF) and southern boundary of the Antarctic Circumpolar Current were evident at all major transects across the Scotia Sea. Chlorophyll concentrations were highest north of the SACCF, with lower values south of the SACCF that increased toward the southern boundary. Lowest chlorophyll concentrations and highest krill densities were observed in the vicinity of the South Orkney Islands. Three geographically distinct size clusters of krill were also mapped across the Scotia Sea. Very large krill (52mm modal length) were sampled in the western Scotia Sea and Drake Passage. Another cluster (48mm modal length, but also containing several samples of intermediate size krill) was mapped in the inshore waters adjacent to the Antarctic Peninsula and extended across the northeastern part of the survey area. Small krill (26mm modal length) were found in the eastern portion of the Scotia Sea in a broad tongue extending from the southern part of the survey area between the South Orkney and South Sandwich Islands north to the eastern end of South Georgia. A preliminary examination of the oceanographic data suggested the small krill may have been transported into the Scotia Sea from the Weddell Sea. Similar biogeographic patterns were apparent in salp demographics and macro-zooplankton species composition mapped from samples collected aboard the *Yuzhmorgeologiya* (approximately one-third of the total number of samples). Krill densities (estimated from the combined data sets) were highest over the continental shelves surrounding the South Shetland, South Orkney, South Georgia and South Sandwich archipelagos. Overall krill density was estimated to be 21.3 g/m<sup>2</sup> over a survey area of 2,065 x 10<sup>3</sup> km<sup>2</sup> for a total biomass of 44.3 million tons (CV 11.4%).

The inshore survey near Cape Shirreff (Figure 3) was accomplished using a 5-m Zodiac configured with a 120kHz echo sounder, an underwater video camera, a CTD, several continuously recording sea surface and meteorological sensors, two GPS receivers, a radar, and emergency equipment. The Zodiac was used to map krill within 15 nautical miles of the Cape while the ship surveyed further offshore. The survey was staged from the field camp and conducted over a 5-day period. Substantial amounts of krill were mapped inshore of the region surveyed by the ship and the feasibility of using a small boat to conduct inshore surveys in Antarctica was demonstrated.

An oceanic frontal zone was mapped along the north side of the South Shetland Islands, running parallel to the continental shelf break and separating Drake Passage water to the north from Bransfield Strait water to the south (Figure 4). The prevailing flow was southwest to northeast; however, both the front and geostrophic flow lines diverged to the north in the vicinity of Elephant Island. Chlorophyll concentrations were above average and highest south of the frontal zone. Highest densities of krill were mapped between King George, Elephant and Clarence Islands and along the shelf break north of the archipelago. Mean krill biomass density in the Elephant Island area was estimated to be 37.5 g/m<sup>2</sup>, higher than that observed in 1999, and in conformance with a long-term cyclic trend. Sampled krill were predominately large and sexually mature; the few immature krill caught were large and probably post-spawning; and only two out of 2,100 specimens processed were juveniles. Virtually all of the sampled krill represented the 1994/95 and 1995/96 year classes. High densities of late krill larval stages suggest an active and

prolonged 1999/2000 spawning season. Demographic analysis of sampled *Salpa thompsoni* suggested the population may have initiated seasonally early production of the over-wintering form. Copepods and larval krill dominated the zooplankton assemblage, although salps were widespread and relatively abundant as well. This, and other aspects of the zooplankton assemblage, suggested that 1999 and 2000 may be classified as transition years between a salp-dominated community and a copepod-dominated community. Acoustically detected layers of myctophid fish were mapped north of the frontal zone and appeared to be associated with the southern boundary of the ACC.

The numbers of chinstrap and gentoo breeding pairs were higher than the previous season and above the three-year mean for the Cape Shirreff monitoring site. Overall reproductive success for chinstrap penguins was lower than average, but fledging weight was slightly higher than average. Conversely, overall reproductive success for gentoo penguins was higher than average, and fledging weight lower than average. Large krill (41 – 55mm) were present in 100% of the sampled diets from both species, while fish were evident in 3% of chinstrap and 80% of gentoo penguin samples. The distribution of foraging trip durations for chinstrap parents were bimodal. Shorter trips (8-hr mode) were initiated between dawn and noon; longer trips (12-hr mode) began later in the day and included the dark period. The median birth date of fur seal pups was two days earlier and total pup production was 5.8% higher than the previous season. Return rates of adult females were comparable to last year, although the return rate for yearlings was lower. Foraging trip duration for lactating females was significantly less than the last two years. As in previous years, an increase in fish and squid in the diet was observed as the season progressed. Teeth were extracted from 80 fur seals for age determination and other demographic studies; operations proceeded according to approved protocols and no adverse reactions were noted.

#### References:

SC-CAMLR-XVIII. 1999. CCAMLR Synoptic Planning Meeting. Appendix D to Report of the Working Group on Ecosystem Monitoring and Management. In: *Report of the Eighteenth Meeting of the Scientific Committee* (SC-CAMLR-XVIII), Annex 4. CCAMLR, Hobart, Australia: 191-202.

SC-CAMLR-XVIII. 1999. CCAMLR 2000 Krill Synoptic Survey: A Description of the Rationale and Design. Appendix E to Report of the Working Group on Ecosystem Monitoring and Management. In: *Report of the Eighteenth Meeting of the Scientific Committee* (SC-CAMLR-XVIII), Annex 4. CCAMLR, Hobart, Australia: 203-225.

SC-CAMLR-XIX. 2000. Report of the B<sub>0</sub> Workshop. Appendix G to Report of the Working Group on Ecosystem Monitoring and Management. In: *Report of the Nineteenth Meeting of the Scientific Committee* (SC-CAMLR-XVIII), Annex 4. CCAMLR, Hobart, Australia.

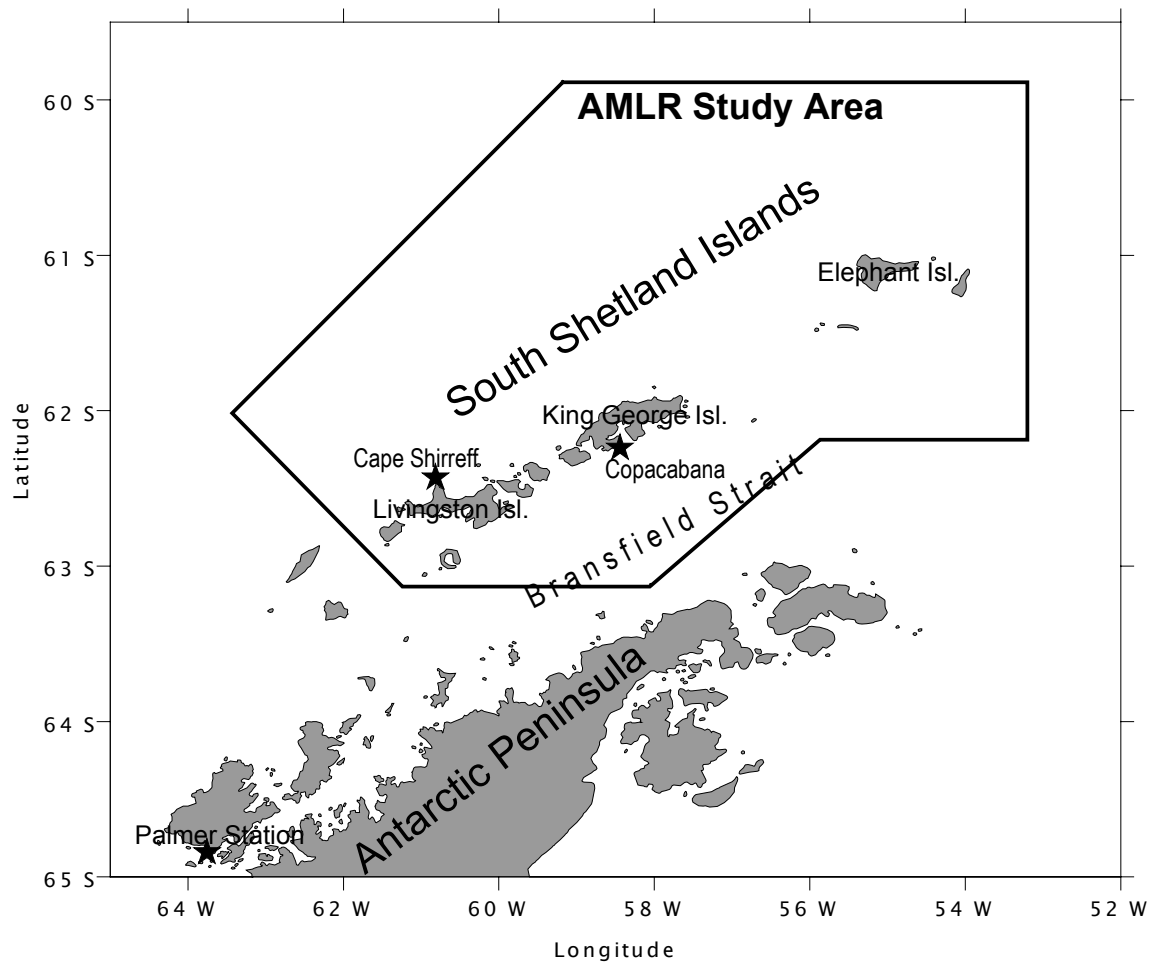


Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff and Copacabana.